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SOME ADVANCES IN RADIO COMMUNICATIONS FOR COMPUTERS

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INTRODUCTION

In this paper we describe an experimental UHF radio computer communication network - THE ALOHA SYSTEM - under development for the past five years at the University of Hawaii [1]. Presently in operation on an experimental basis, the existing ALOHA SYSTEM computer-communication network uses two 24,000 baud channels at 407.350 MHz and at 413.475 MHz in the upper UHF band. The system uses packet switching techniques similar to that employed by the ARPANET [2], in conjunction with a novel form of random-access radio channel multiplexing. Recently THE ALOHA SYSTEM has become the first satellite node on the ARPANET, in which a TIP (Terminal Interface Processor) [3] located at the University of Hawaii campus communicates through a 50 kilobit data channel using INTELSAT IV with the NASA/AMES TIP and into the ARPANET. The 50 kilobit satellite channel occupies a single PCM voice channel on INTELSAT IV. We will describe some of our current activities in this paper and present a look into the future of our project.

THE ALOHA SYSTEM

In Figure 1 we show the present configuration of THE ALOHA SYSTEM. The central computer of the University, an IBM 360/65 with 2.5 MBytes of core memory presently runs under OS MVT and in addition to background batch, runs two timesharing systems, APL and TSO. THE ALOHA SYSTEM is one of the TSO users and is connected to the 360 computer via the HP 2115A computer which serves as a data-concentrator and multiplexor. Since the functions of the 2115A machine is much like that of the Interface Message Processor (IMP) [4] used in the ARPANET, we have dubbed the 2115A the MENEHUNE, a legendary Hawaiian elf. The modem operates at 24,000 baud and uses differential phase shift keyed modulation. The demodulator has been specially designed for our application so as to optimally operate on the coherent signal by using a phase-locked-loop to recover bit timing and a matched filter to recover the signal in the presence of noise. The transmitter-receivers are primarily standard commercial transceivers, modified to accommodate the system specifications. On the terminal end, the central piece of equipment is the communications module developed by THE ALOHA SYSTEM called the Terminal Control Unit (TCU). The TCU consists of a UHF antenna, transceiver, modem and buffer control unit, and is shown in Figure 2. Thus the TCU duplicates on the terminal end, all of the separate pieces of equipment on the HOST side. A TCU can interface a wide variety of terminals operating at speeds up to 24,000 baud. At present, we have connected teletype terminals, alphanumeric displays, graphics processors and minicomputers to the TCU's with equal ease.

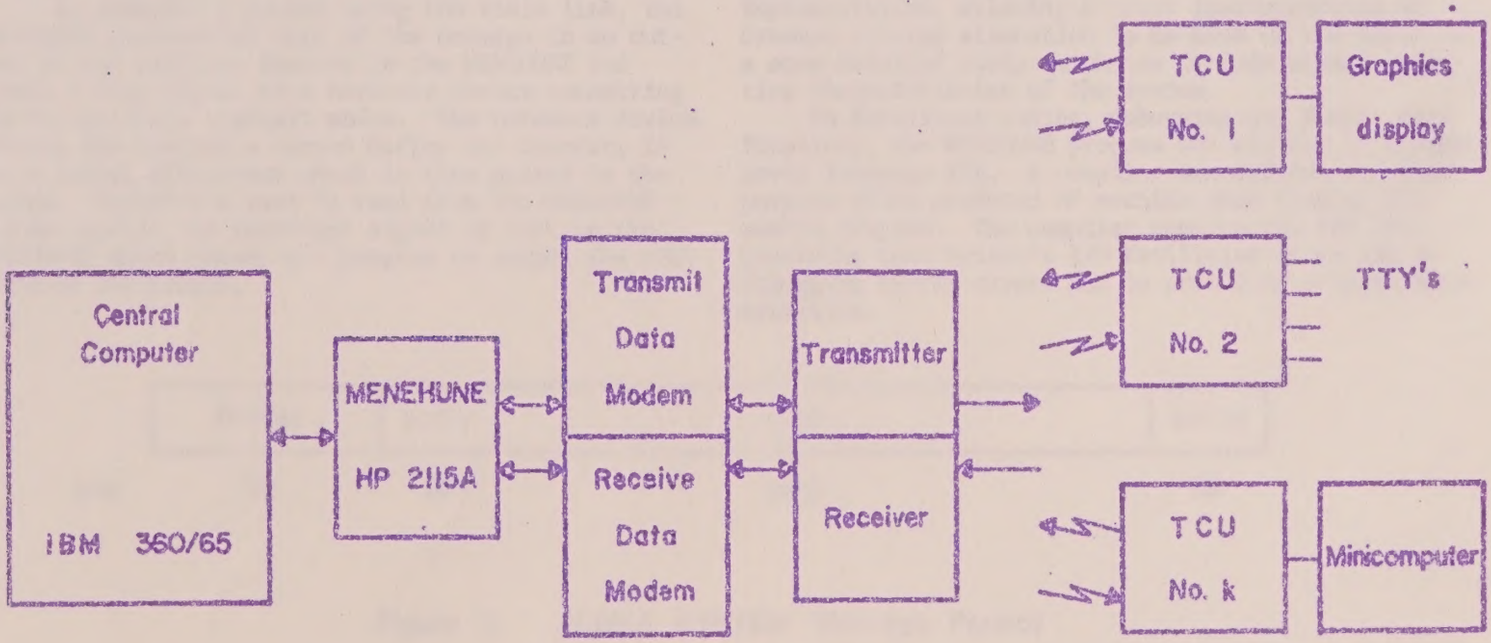
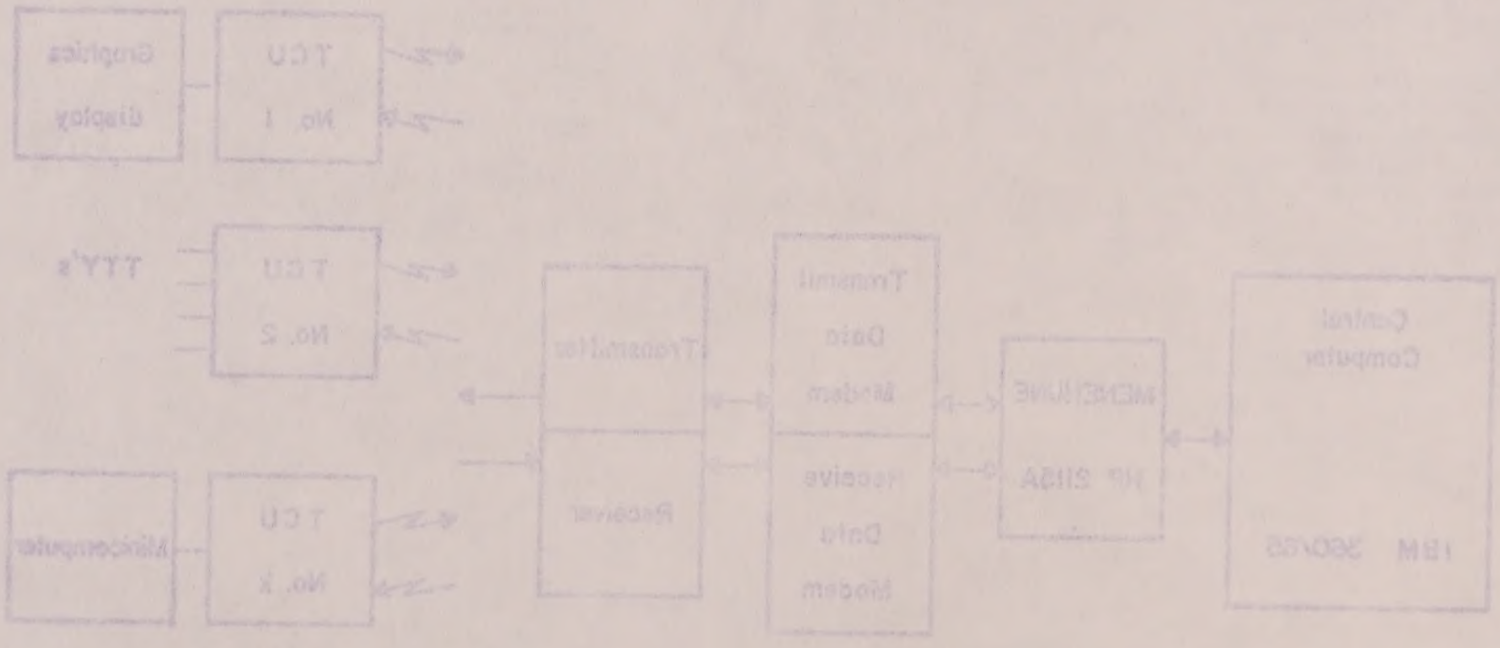


Figure 1. THE ALOHA SYSTEM


TTY's
TCU
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Terminal
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MODCOMP
MP 2105A
IBM 360/65

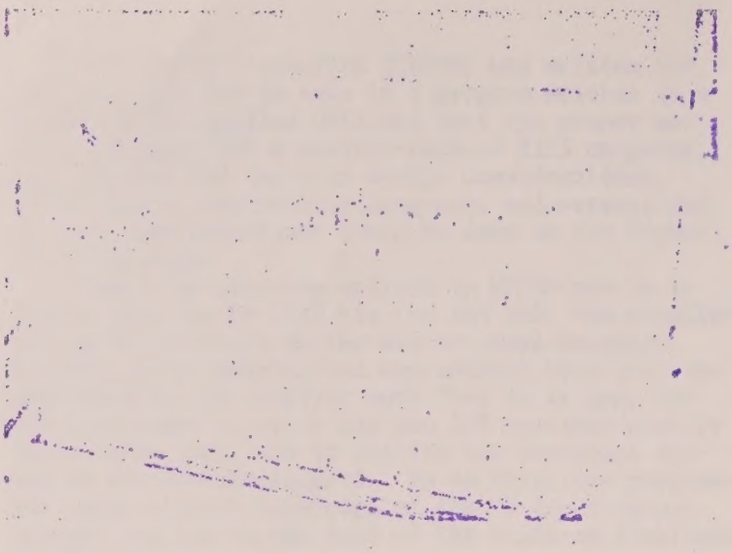

Figure 2. Terminal Control Unit (TCU)

ALOHA INTERFACE*

In order to connect a remote station into the ALOHA channel it is necessary to provide buffering up to a full packet of data together with automatic generation of certain identification, control and parity information. This information is generated in a hardware buffer/control interface unit from each user console to a modem. The buffer/control unit also provides for reception of messages and acknowledgements into its remote station, rejection of unwanted packets and automatic retransmission of packets not receiving an acknowledgement [5]. In the case of buffered terminals, intelligent terminals and minicomputers some of the buffer/control functions may be handled by software packages in the remote station.

To transmit a packet using the radio link, the MENEHUNE places each word of the message in an output buffer register located in the MENEHUNE and sends a flag signal to a hardware device connecting it to the radio transmit modem. The hardware device stores the word in a second buffer and converts it to a serial bit-stream which is then passed to the modem. Whenever a word is read from the MENEHUNE output buffer, an interrupt signal is sent to the MENEHUNE which causes the program to output the next word of the packet.

In addition to the message words, control words are transferred between the MENEHUNE and the radio link and between the MENEHUNE and the 360. Each packet in the radio link is preceeded by two control words (the packet "header") and a header parity word, and each packet's text is followed by a text parity word (Figure 3). At this time the hardware circuits between the radio modems and the MENEHUNE perform the tasks of both parity and syndrome generation. The parity words are inserted into the packet by the hardware prior to entering the transmit modem, and the syndrome words are inserted in place of the received parity words of the packet prior to being placed in the MENEHUNE input buffer register. Consideration is being given to incorporating parity and syndrome generation in the MENEHUNE multiplexor program. A word with all bits set to 'one' is also sent to the MENEHUNE by the hardware units preceeding the start of each packet, providing synchronization for the MENEHUNE program.

A control word is sent between the MENEHUNE and the 360 prior to a packet transfer in either direction. This word contains the terminal ID number and a packet length indicator (now restricted to 20 or 40 words). The length information allows the block size to be specified so that direct-memory-access transfers can be made by both the 360 and the MENEHUNE.

The program is modular in design, allowing the processing functions for a particular user channel to be easily changed. Editing functions are localized within each user channel module, allowing the editing characters used by a particular terminal to be changed without affecting the other modules in the program. Fixed buffer areas are assigned for each system user in the program. Because of the relative data transmission rates of the user MENEHUNE and MENEHUNE-360 links, it is necessary to store only one packet for each user within the MENEHUNE at any particular time (although the most recent packet sent to a remote station will be kept in storage for user retransmission requests). This fact and the small number of users anticipated for the initial system led to the choice of fixed storage allocation in the current implementation, allowing a later implementation of dynamic storage allocation to be made on the basis of a more detailed study which can include actual operating characteristics of the system.

To facilitate coding, debugging and future modifications, the MENEHUNE program was written in a high-level language XPL. A compiler was written for this purpose which produced HP machine code from an XPL source program. The compiler runs on the IBM 360, providing that system's I/O facilities as an aid in debugging syntax errors and in producing program documentation.

	header	parity	text	parity
bits	32	16	640	16

Figure 3. ALOHA SYSTEM Message Format

* Portions of this section were obtained from [5].

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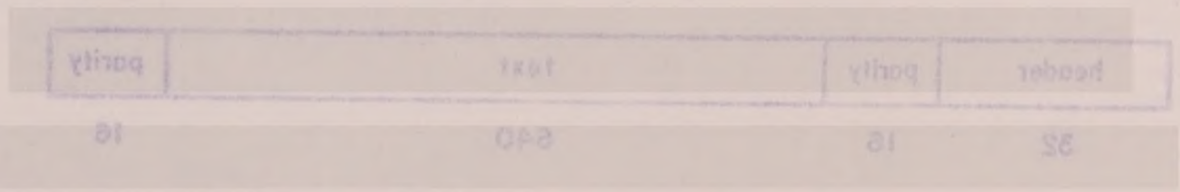

https://archive.org/details/temporary-note-010

The MENEHUNE compiler (HPCOM) was written for use on an IBM 360 to take in a program written in a subset of XPL (called HPL) and emit the proper machine language for a Hewlett-Packard 2115 computer. The compiler had two main design considerations, efficiency of the machine language, and versatility, so that most operations could be done in the higher level language.

Since the programs written in HPCOM are to be loaded into the HP 2115 via the IBM 360, the compiler has no input-output in the higher level language. However, many features and conventions have been implemented in the compiler such that it is easy for the programmer to write his own I/O routines exactly as he wants them, and to utilize the interrupt system of the Hewlett-Packard. To do this, the programmer needs a basic knowledge of the HP input-output system, and how to use some of the built-in functions of the compiler.

The output of the compiler is the raw machine code for the Hewlett-Packard ready to be loaded into the machine, a printed output of the source program, the machine code resulting from each statement with explanation in assembly code for readability, and error statements.

PRESENT STATE OF THE ALOHA SYSTEM

At present THE ALOHA SYSTEM has seven TCU's in operation which service a number of teletypes, Hazeltine terminals, and a graphics terminal. In addition we have interfaced an IMLAC display computer and a HP 2114 minicomputer into the ALOHA channels. In these two latter cases the buffer control function of the TCU is handled by a software package in the IMLAC and in the HP 2114. Because of the efficient use of channel capacity by the ALOHA burst random access communication method the present channel is only lightly loaded. We have calculated that well over 500 active alphanumeric terminals could use the present communication channels of THE ALOHA SYSTEM.

At present we are performing system studies to investigate properties of the random-access channel used in different modes (unsynchronized, synchronized, contention, file scheduling, multiple frequency, etc.) by both analytical and computer simulation studies. We are also investigating the effects of different channel protocols upon system performance. We have also purchased an INTEL CPU on a single integrated circuit chip for the purpose of developing a TCU with considerably more flexibility than the present hard-wired versions. The TCU-on-a-chip will enable the system to respond to a variety of different transmission protocols, including variable length packets and character-by-character transmission. Various error control procedures can also be studied and implemented with this new TCU.

Our main emphasis, however, is in the area of satellite data communications, which we describe in the following section.

SATELLITE COMMUNICATIONS

Because of the geographic isolation of Hawaii, one of the original objectives of THE ALOHA SYSTEM project was to study the feasibility of computer communications by means of satellite. With the development of digital communication systems by COMSAT in which data at the rate of 50 baud can be transmitted through a single voice channel [7], data transmission by satellite has become both technologically and economically feasible.

There is a basic and important difference between the use of a satellite channel and a wire channel for data communications. The satellite channel is a broadcast channel as opposed to a point-to-point wire channel, so that a single voice channel, say between ground stations A and B can be used in broadcast mode among any set of ground stations, providing a full broadcast capability of two 50 baud channels. Thus a single commercial satellite voice channel could be employed with the following characteristics: (1) The single voice channel could provide two up-link and two down link 50 baud data channels. (2) Each of these four channels could be simultaneously available to any COMSAT ground station in sight of the satellite.

During the past year we have initiated two specific research projects for satellite extension of THE ALOHA SYSTEM and several theoretical studies involving the unique properties of satellite channels. The first of the projects involves the use of large commercial ground stations and the establishment of an ARPANET SATELLITE SYSTEM; the second involves the use of small inexpensive ground stations in a joint research effort with NASA/AMES. In regard to the ARPANET SATELLITE SYSTEM, we have been involved in a joint study with ARPA, Bolt Beranek and Newman, Xerox Data Systems and UCLA to design a suitable protocol for packet communications via satellite. These studies are of a tentative nature at present and will not be reported on in this paper. In December 1972, a digital communication subsystem was installed between the COMSAT ground stations at Paumalu, Hawaii, and Jamesburg, California. The first subscriber of this service was THE ALOHA SYSTEM, which, with its newly installed TIP, became the first operational satellite node on the ARPANET. As of this moment (December 1972) the IBM 360 computer is connected as a HOST computer of the Hawaii TIP. Shortly we expect to connect the MENEHUNE to the TIP as a second HOST. With the TIP in operation, we plan to experiment with system protocols and sharing of remote data bases.

The second satellite project involves the use of the NASA satellite ATS-1 using small, inexpensive ground stations, which cost less than $5,000 each. Thus far we have progressed to the point where a random access burst mode data channel is in operation between the University of Hawaii and NASA/AMES Research Center in California. Early in 1973 this network will be joined by the University of Alaska. During the following year we plan to interface this channel into computers near each of these ground stations, extend the number of ground stations to other sites, including possibly universities in Japan and Taiwan and establish a small ground station satellite network on an experimental basis.

It is now quite apparent that satellite communications will become the main emphasis of THE ALOHA SYSTEM. In addition to the two hardware projects described above THE ALOHA SYSTEM has begun a two year feasibility study of a Pacific Educational Computer Network using advanced data communication techniques to link computers in developed countries and developing countries in the Pacific. This study is a cooperative effort of THE ALOHA SYSTEM and Tohoku University in Japan and is supported by the U.S. National Science Foundation and the Japan Society for the Promotion of Science.

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[4] F.E. Heart, R.E. Kahn, S.M. Ornstein, W.R. Crowther, and D.C. Walden, "The Interface Message Processor for the ARPA Computer Network," SJCC 1970, pp. 551-567.

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